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Roy et al.

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(54) **SURGICAL FORCEPS**

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(73) Assignee: **Covidien LP**, Mansfield, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(22) Filed: **Feb. 20, 2015**

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(51) **Int. Cl.**
A61B 18/14 (2006.01)
A61B 18/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 18/1442*** (2013.01); ***A61B 18/1445*** (2013.01); *A61B 2018/0063* (2013.01); *A61B 2018/00428* (2013.01); *A61B 2018/00607* (2013.01); *A61B 2018/146* (2013.01);
(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

D249,549	S	9/1978	Pike
D263,020	S	2/1982	Rau, III
D295,893	S	5/1988	Sharkany et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN	201299462	9/2009
DE	2415263 A1	10/1975

(Continued)

OTHER PUBLICATIONS

Burdette et al. "In Vivo Probe Measurement Technique for Determining Dielectric Properties at VHF Through Microwave Frequencies", IEEE Transactions on Microwave Theory and Techniques, vol. MTT-28, No. 4, Apr. 1980 pp. 414-427.

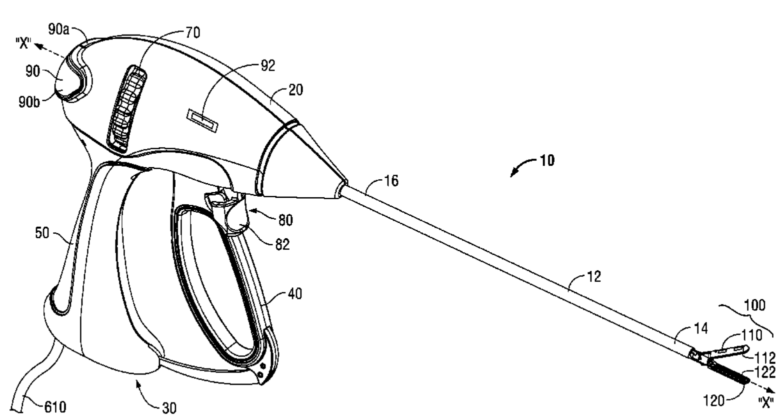
(Continued)

Primary Examiner — Brian T Gedeon
Assistant Examiner — Ankit Tejani

(57) **ABSTRACT**

An end effector of a forceps includes first and second jaw members movable between spaced-apart and approximated positions for grasping tissue. Each jaw member includes a tissue sealing plate that is selectively energizable. The tissue sealing plates are configured to conduct energy therebetween and though tissue to seal tissue. A knife includes a distal surface and an upper surface. The knife is selectively translatable between a retracted position and an extended position wherein the knife extends between the jaw members. The distal surface is configured for dynamic tissue cutting upon translation of the knife from the retracted to the extended position. The upper surface is configured for static tissue cutting with the knife in the extended position. The knife is selectively energizable and is configured to conduct energy between the knife and one or both of the tissue sealing plates and through tissue to electrically cut tissue.

19 Claims, 6 Drawing Sheets



(52) **U.S. Cl.**
CPC . *A61B2018/1412* (2013.01); *A61B 2018/1455* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

D295,894 S 5/1988 Sharkany et al.
D298,353 S 11/1988 Manno
D299,413 S 1/1989 DeCarolis
D343,453 S 1/1994 Noda
D348,930 S 7/1994 Olson
D349,341 S 8/1994 Lichtman et al.
D354,564 S 1/1995 Medema
D358,887 S 5/1995 Feinberg
5,431,674 A 7/1995 Basile et al.
D384,413 S 9/1997 Zlock et al.
H1745 H 8/1998 Paraschac
D402,028 S 12/1998 Grimm et al.
D408,018 S 4/1999 McNaughton
D416,089 S 11/1999 Barton et al.
6,004,335 A 12/1999 Vaitekunas et al.
D424,694 S 5/2000 Tetzlaff et al.
D425,201 S 5/2000 Tetzlaff et al.
H1904 H 10/2000 Yates et al.
D449,886 S 10/2001 Tetzlaff et al.
D453,923 S 2/2002 Olson
D454,951 S 3/2002 Bon
D457,958 S 5/2002 Dycus et al.
D457,959 S 5/2002 Tetzlaff et al.
H2037 H 7/2002 Yates et al.
D465,281 S 11/2002 Lang
D466,209 S 11/2002 Bon
D493,888 S 8/2004 Reschke
D496,997 S 10/2004 Dycus et al.
D499,181 S 11/2004 Dycus et al.
D502,994 S 3/2005 Blake, III
D509,297 S 9/2005 Wells
D525,361 S 7/2006 Hushka
D531,311 S 10/2006 Guerra et al.
D533,274 S 12/2006 Visconti et al.
D533,942 S 12/2006 Kerr et al.
D535,027 S 1/2007 James et al.
D538,932 S 3/2007 Malik
D541,418 S 4/2007 Schechter et al.
D541,611 S 5/2007 Aglassinger
D541,938 S 5/2007 Kerr et al.
D545,432 S 6/2007 Watanabe
D547,154 S 7/2007 Lee
D564,662 S 3/2008 Moses et al.
D567,943 S 4/2008 Moses et al.
D575,395 S 8/2008 Hushka
D575,401 S 8/2008 Hixson et al.
D582,038 S 12/2008 Swoyer et al.
D617,900 S 6/2010 Kingsley et al.
D617,901 S 6/2010 Unger et al.
D617,902 S 6/2010 Twomey et al.
D617,903 S 6/2010 Unger et al.
D618,798 S 6/2010 Olson et al.
D621,503 S 8/2010 Otten et al.
D627,462 S 11/2010 Kingsley
D628,289 S 11/2010 Romero
D628,290 S 11/2010 Romero
D630,324 S 1/2011 Reschke
7,951,150 B2 5/2011 Johnson et al.
D649,249 S 11/2011 Guerra
D649,643 S 11/2011 Allen, IV et al.
D661,394 S 6/2012 Romero et al.
8,333,765 B2 12/2012 Johnson et al.
8,454,602 B2 6/2013 Kerr et al.
8,523,898 B2 9/2013 Bucciaglia et al.
8,529,566 B2 9/2013 Kappus et al.
8,568,408 B2 10/2013 Townsend et al.
8,591,510 B2 11/2013 Allen, IV et al.
8,628,557 B2 1/2014 Collings et al.
8,679,098 B2 3/2014 Hart
8,679,140 B2 3/2014 Butcher
8,685,009 B2 4/2014 Chernov et al.
8,685,056 B2 4/2014 Evans et al.
8,696,667 B2 4/2014 Guerra et al.
8,702,737 B2 4/2014 Chojin et al.
8,702,749 B2 4/2014 Twomey
8,745,840 B2 6/2014 Hempstead et al.
8,747,413 B2 6/2014 Dycus
8,747,434 B2 6/2014 Larson et al.
8,752,264 B2 6/2014 Ackley et al.
8,756,785 B2 6/2014 Allen, IV et al.
8,845,636 B2 9/2014 Allen, IV et al.
8,852,185 B2 10/2014 Twomey
8,864,753 B2 10/2014 Nau, Jr. et al.
8,864,795 B2 10/2014 Kerr et al.
8,887,373 B2 11/2014 Brandt et al.
8,888,771 B2 11/2014 Twomey
8,900,232 B2 12/2014 Ourada
8,939,972 B2 1/2015 Twomey
8,961,513 B2 2/2015 Allen, IV et al.
8,961,514 B2 2/2015 Garrison
8,961,515 B2 2/2015 Twomey et al.
8,968,283 B2 3/2015 Kharin
8,968,305 B2 3/2015 Dumbauld et al.
8,968,306 B2 3/2015 Unger
8,968,307 B2 3/2015 Evans et al.
8,968,308 B2 3/2015 Horner et al.
8,968,309 B2 3/2015 Roy et al.
8,968,310 B2 3/2015 Twomey et al.
8,968,317 B2 3/2015 Evans et al.
8,968,360 B2 3/2015 Garrison et al.
2003/0078577 A1* 4/2003 Truckai et al. 606/51
2007/0118111 A1 5/2007 Weinberg
2008/0039835 A1 2/2008 Johnson et al.
2008/0319442 A1 12/2008 Unger et al.
2010/0137854 A1 6/2010 Hosier
2010/0179545 A1* 7/2010 Twomey et al. 606/51
2011/0004210 A1 1/2011 Johnson et al.
2011/0046623 A1 2/2011 Reschke
2011/0054467 A1 3/2011 Mueller et al.
2012/0029637 A1 2/2012 Ragab et al.
2012/0239034 A1 9/2012 Horner et al.
2012/0259331 A1 10/2012 Garrison
2012/0296205 A1 11/2012 Chernov et al.
2012/0296238 A1 11/2012 Chernov et al.
2012/0296239 A1 11/2012 Chernov et al.
2012/0296317 A1 11/2012 Chernov et al.
2012/0296323 A1 11/2012 Chernov et al.
2012/0296324 A1 11/2012 Chernov et al.
2012/0303025 A1 11/2012 Garrison
2012/0303026 A1 11/2012 Dycus et al.
2012/0310240 A1 12/2012 Olson et al.
2012/0323238 A1 12/2012 Tyrrell et al.
2012/0330308 A1 12/2012 Joseph
2012/0330309 A1 12/2012 Joseph
2013/0018364 A1 1/2013 Chernov et al.
2013/0018372 A1 1/2013 Sims et al.
2013/0022495 A1 1/2013 Allen, IV et al.
2013/0046295 A1 2/2013 Kerr et al.
2013/0060250 A1 3/2013 Twomey et al.
2013/0066318 A1 3/2013 Kerr
2013/0071282 A1 3/2013 Fry
2013/0072927 A1 3/2013 Allen, IV et al.
2013/0079760 A1 3/2013 Twomey et al.
2013/0079774 A1 3/2013 Whitney et al.
2013/0085491 A1 4/2013 Twomey et al.
2013/0085496 A1 4/2013 Unger et al.
2013/0085516 A1* 4/2013 Kerr et al. 606/167
2013/0103030 A1 4/2013 Garrison
2013/0103031 A1 4/2013 Garrison
2013/0138101 A1 5/2013 Kerr
2013/0138129 A1 5/2013 Garrison et al.
2013/0144284 A1 6/2013 Behnke, II et al.
2013/0178852 A1 7/2013 Allen, IV et al.
2013/0185922 A1 7/2013 Twomey et al.
2013/0197503 A1 8/2013 Orszulak
2013/0226178 A1 8/2013 Brandt et al.
2013/0245623 A1 9/2013 Twomey
2013/0253489 A1 9/2013 Nau, Jr. et al.
2013/0255063 A1 10/2013 Hart et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0274736	A1	10/2013	Garrison
2013/0289561	A1	10/2013	Waaler et al.
2013/0296848	A1	11/2013	Allen, IV et al.
2013/0296856	A1	11/2013	Unger et al.
2013/0296922	A1	11/2013	Allen, IV et al.
2013/0296923	A1	11/2013	Twomey et al.
2013/0304058	A1	11/2013	Kendrick
2013/0304059	A1	11/2013	Allen, IV et al.
2013/0304066	A1	11/2013	Kerr et al.
2013/0325057	A1	12/2013	Larson et al.
2014/0005663	A1	1/2014	Heard et al.
2014/0005666	A1	1/2014	Moua et al.

FOREIGN PATENT DOCUMENTS

DE	02514501	A1	10/1976
DE	2627679	A1	1/1977
DE	03423356	C2	6/1986
DE	03612646	A1	4/1987
DE	8712328	U1	2/1988
DE	04303882	C2	2/1995
DE	04403252	A1	8/1995
DE	19515914	C1	7/1996
DE	19506363	A1	8/1996
DE	29616210	U1	11/1996
DE	19608716	C1	4/1997
DE	19751106	A1	5/1998
DE	19751108	A1	5/1999
DE	19946527	C1	7/2001
DE	20121161	U1	4/2002
DE	10045375	C2	10/2002
DE	202007009165	U1	8/2007
DE	202007009317	U1	8/2007
DE	202007009318	U1	8/2007
DE	10031773	B4	11/2007
DE	202007016233	U1	1/2008
DE	19738457	B4	1/2009
DE	102004026179	B4	1/2009
DE	102008018406	B3	7/2009
EP	1159926	A3	3/2003
EP	1769765		4/2007
JP	61-501068		9/1984
JP	10-24051	A	1/1989
JP	11-47150	A	6/1989
JP	6-502328		3/1992
JP	5-5106		1/1993
JP	05-40112		2/1993
JP	0006030945	A	2/1994
JP	6-121797	A	5/1994
JP	6-285078	A	10/1994
JP	6-511401		12/1994
JP	06343644	A	12/1994
JP	07265328	A	10/1995
JP	8-56955		5/1996
JP	08252263	A	10/1996
JP	8-289895	A	11/1996
JP	8-317934	A	12/1996
JP	8-317936	A	12/1996
JP	9-10223	C	1/1997
JP	9-122138	A	5/1997
JP	0010000195	A	1/1998
JP	10-155798	A	6/1998
JP	11-070124	A	3/1999
JP	11-169381	A	6/1999
JP	11-192238	A	7/1999
JP	11244298	A	9/1999
JP	2000-102545	A	4/2000
JP	2000342599	A	12/2000
JP	2000350732	A	12/2000
JP	2001008944	A	1/2001
JP	2001029356	A	2/2001
JP	2001-03400		4/2001
JP	2001128990	A	5/2001
JP	2001-190564	A	7/2001
JP	2002-136525	A	5/2002
JP	2002-528166	A	9/2002
JP	2003-175052	A	6/2003
JP	2003245285	A	9/2003
JP	2004-517668	A	6/2004
JP	2004-528869	A	9/2004
JP	2005-253789	A	9/2005
JP	2006-015078	A	1/2006
JP	2006-501939	A	1/2006
JP	2006-095316	A	4/2006
JP	2011125195	A	6/2011
SU	401367	A1	11/1974
WO	0036986	A1	6/2000
WO	0059392	A1	10/2000
WO	0115614	A1	3/2001
WO	01/28444	A1	4/2001
WO	0154604	A1	8/2001
WO	0245589	A3	9/2002
WO	2006/021269	A1	3/2006
WO	2005110264	A3	4/2006
WO	2008/040483	A1	4/2008

OTHER PUBLICATIONS

Carus et al., "Initial Experience With the LigaSure Vessel Sealing System in Abdominal Surgery" Innovations That Work, Jun. 2002.

Heniford et al. "Initial Research and Clinical Results with an Electrothermal Bipolar Vessel Sealer" Oct. 1999.

Heniford et al. "Initial Results with an Electrothermal Bipolar Vessel Sealer" Surgical Endoscopy (2000) 15:799-801.

Herman et al., "Laparoscopic Intestinal Resection With the LigaSure Vessel Sealing System: A Case Report"; Innovations That Work, Feb. 2002.

Koyle et al., "Laparoscopic Palomo Varicocele Ligation in Children and Adolescents" Pediatric Endosurgery & Innovative Techniques, vol. 6, No. 1, 2002.

W. Scott Helton, "LigaSure Vessel Sealing System: Revolutionary Hemostasis Product for General Surgery"; Sales/Product Literature 1999.

LigaSure Vessel Sealing System, the Seal of Confidence in General, Gynecologic, Urologic, and Laparaoscopic Surgery; Sales/Product Literature; Apr. 2002.

Joseph Ortenberg "LigaSure System Used in Laparoscopic 1st and 2nd Stage Orchiopexy" Innovations That Work, Nov. 2002.

Sigel et al. "The Mechanism of Blood Vessel Closure by High Frequency Electrocoagulation" Surgery Gynecology & Obstetrics, Oct. 1965 pp. 823-831.

Sampayan et al, "Multilayer Ultra-High Gradient Insulator Technology" Discharges and Electrical Insulation in Vacuum, 1998. Netherlands Aug. 17-21, 1998; vol. 2, pp. 740-743.

Paul G. Horgan, "A Novel Technique for Parenchymal Division During Hepatectomy" The American Journal of Surgery, vol. 181, No. 3, Apr. 2001 pp. 236-237.

Benaron et al., "Optical Time-Of-Flight and Absorbance Imaging of Biologic Media", Science, American Association for the Advancement of Science, Washington, DC, vol. 259, Mar. 5, 1993, pp. 1463-1466.

Olsson et al. "Radical Cystectomy in Females" Current Surgical Techniques in Urology, vol. 14, Issue 3, 2001.

Palazzo et al. "Randomized clinical trial of Ligasure versus open haemorrhoidectomy" British Journal of Surgery 2002, 89, 154-157.

Levy et al. "Randomized Trial of Suture Versus Electrosurgical Bipolar Vessel Sealing in Vaginal hysterectomy" Obstetrics & Gynecology, vol. 102, No. 1, Jul. 2003.

"Reducing Needlestick Injuries in the Operating Room" Sales/Product Literature 2001.

Bergdahl et al. "Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator" J. Neurosurg, vol. 75, Jul. 1991, pp. 148-151.

Strasberg et al. "A Phase I Study of the LigaSure Vessel Sealing System in Hepatic Surgery" Section of HPB Surger, Washington University School of Medicine, St. Louis MO, Presented at AHPBA, Feb. 2001.

Sayfan et al. "Sutureless Closed Hemorrhoidectomy: A New Technique" Annals of Surgery vol. 234 No. 1 Jul. 2001; pp. 21-24.

(56) **References Cited**

OTHER PUBLICATIONS

Levy et al., "Update on Hysterectomy—New Technologies and Techniques" OBG Management, Feb. 2003.
Dulemba et al. "Use of a Bipolar Electrothermal Vessel Sealer in Laparoscopically Assisted Vaginal Hysterectomy" Sales/Product Literature; Jan. 2004.
Strasberg et al., "Use of a Bipolar Vessel-Sealing Device for Parenchymal Transection During Liver Surgery" Journal of Gastrointestinal Surgery, vol. 6, No. 4, Jul./Aug. 2002 pp. 569-574.
Sengupta et al., "Use of a Computer-Controlled Bipolar Diathermy System in Radical Prostatectomies and Other Open Urological Surgery" ANZ Journal of Surgery (2001) 71.9 pp. 538-540.
Rothenberg et al. "Use of the LigaSure Vessel Sealing System in Minimally Invasive Surgery in Children" Int'l Pediatric Endosurgery Group (IPEG) 2000.
Crawford et al. "Use of the LigaSure Vessel Sealing System in Urologic Cancer Surgery" Grand Rounds in Urology 1999 vol. 1 Issue 4 pp. 10-17.
Craig Johnson, "Use of the LigaSure Vessel Sealing System in Bloodless Hemorrhoidectomy" Innovations That Work, Mar. 2000.
Levy et al. "Use of a New Energy-based Vessel Ligation Device During Vaginal Hysterectomy" Int'l Federation of Gynecology and Obstetrics (FIGO) World Congress 1999.
Barbara Levy, "Use of a New Vessel Ligation Device During Vaginal Hysterectomy" FIGO 2000, Washington, D.C.
E. David Crawford "Use of a Novel Vessel Sealing Technology in Management of the Dorsal Veinous Complex" Sales/Product Literature 2000.
Jarrett et al., "Use of the LigaSure Vessel Sealing System for Peri-Hilar Vessels in Laparoscopic Nephrectomy" Sales/Product Literature 2000.
Crouch et al. "A Velocity-Dependent Model for Needle Insertion in Soft Tissue" MICCAI 2005; LNCS 3750 pp. 624-632, Dated: 2005.
McLellan et al. "Vessel Sealing for Hemostasis During Pelvic Surgery" Int'l Federation of Gynecology and Obstetrics FIGO World Congress 2000, Washington, D.C.
McLellan et al. "Vessel Sealing for Hemostasis During Gynecologic Surgery" Sales/Product Literature 1999.
U.S. Appl. No. 08/926,869, filed Sep. 10, 1997.
U.S. Appl. No. 09/177,950, filed Oct. 23, 1998.
U.S. Appl. No. 09/387,883, filed Sep. 1, 1999.
U.S. Appl. No. 09/591,328, filed Jun. 9, 2000.
U.S. Appl. No. 12/336,970, filed Dec. 17, 2008.
Michael Choti, "Abdominoperineal Resection with the LigaSure Vessel Sealing System and LigaSure Atlas 20 cm Open Instrument" ; Innovations That Work, Jun. 2003.
Chung et al., "Clinical Experience of Sutureless Closed Hemorrhoidectomy with LigaSure" Diseases of the Colon & Rectum vol. 46, No. 1 Jan. 2003.
Tinkcler L.F., "Combined Diathermy and Suction Forceps" , Feb. 6, 1967 (Feb. 6, 1965), British Medical Journal Feb. 6, 1976, vol. 1, nr. 5431 p. 361, ISSN: 0007-1447.
Carbonell et al., "Comparison of theGyrus PlasmaKinetic Sealer and the Valleylab LigaSure Device in the Hemostasis of Small, Medium, and Large-Sized Arteries" Carolinas Laparoscopic and Advanced Surgery Program, Carolinas Medical Center, Charlotte, NC; Date: Aug. 2003.
Peterson et al. "Comparison of Healing Process Following Ligation with Sutures and Bipolar Vessel Sealing" Surgical Technology International (2001).
"Electrosurgery: A Historical Overview" Innovations in Electrosurgery; Sales/Product Literature; Dec. 31, 2000.
Johnson et al. "Evaluation of a Bipolar Electrothermal Vessel Sealing Device in Hemorrhoidectomy" Sales/Product Literature; Jan. 2004.
E. David Crawford "Evaluation of a New Vessel Sealing Device in Urologic Cancer Surgery" Sales/Product Literature 2000.
Johnson et al. "Evaluation of the LigaSure Vessel Sealing System in Hemorrhoidectormy" American College of Surgeons (ACS) Clinicla Congress Poster (2000).
Muller et al., "Extended Left Hemicolectomy Using the LigaSure Vessel Sealing System" Innovations That Work, Sep. 1999.
Kennedy et al. "High-burst-strength, feedback-controlled bipolar vessel sealing" Surgical Endoscopy (1998) 12: 876-878.
European Search Report from corresponding application EP 12191975 dated Jan. 31, 2013.

* cited by examiner

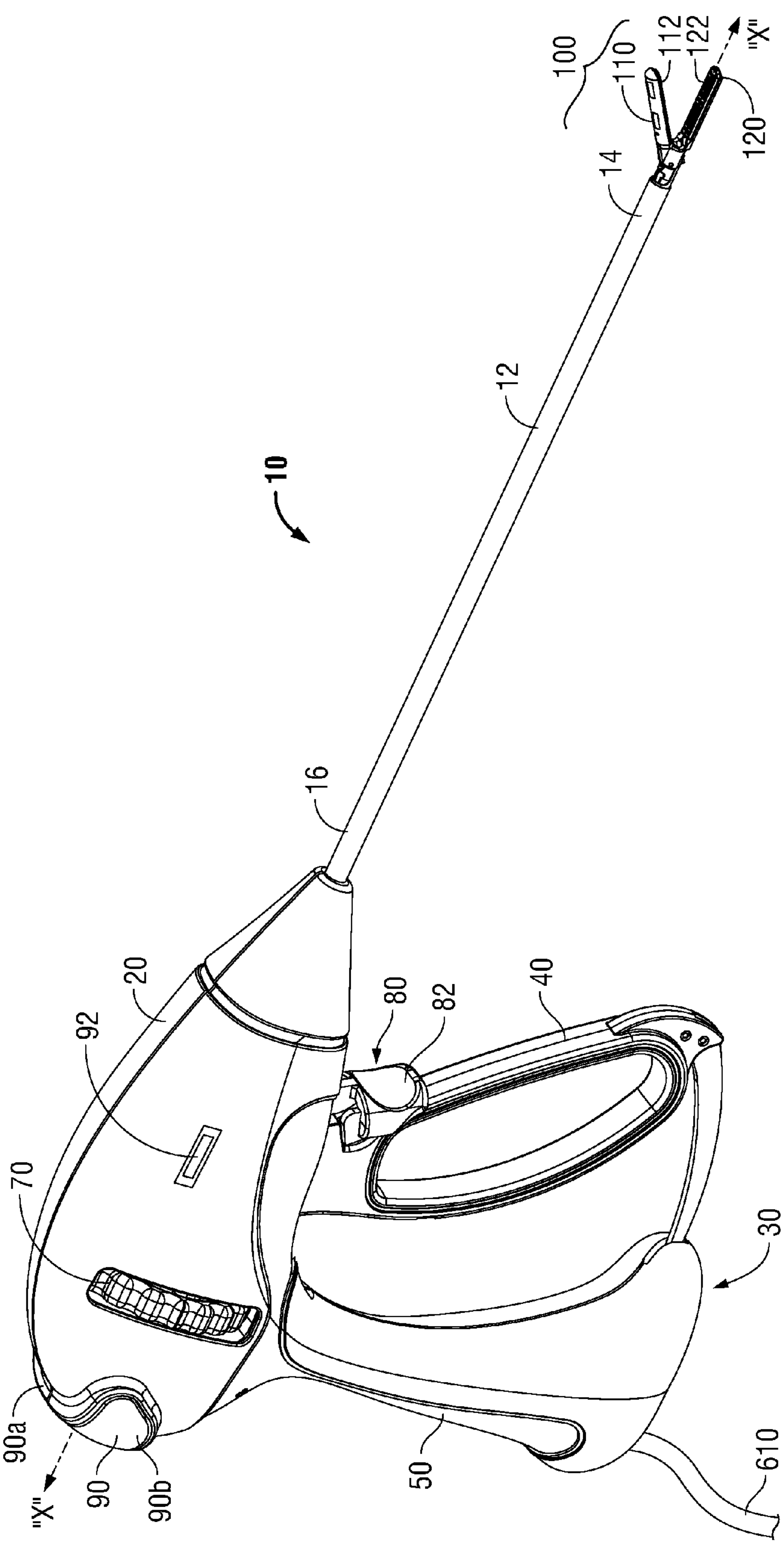

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FIG. 1

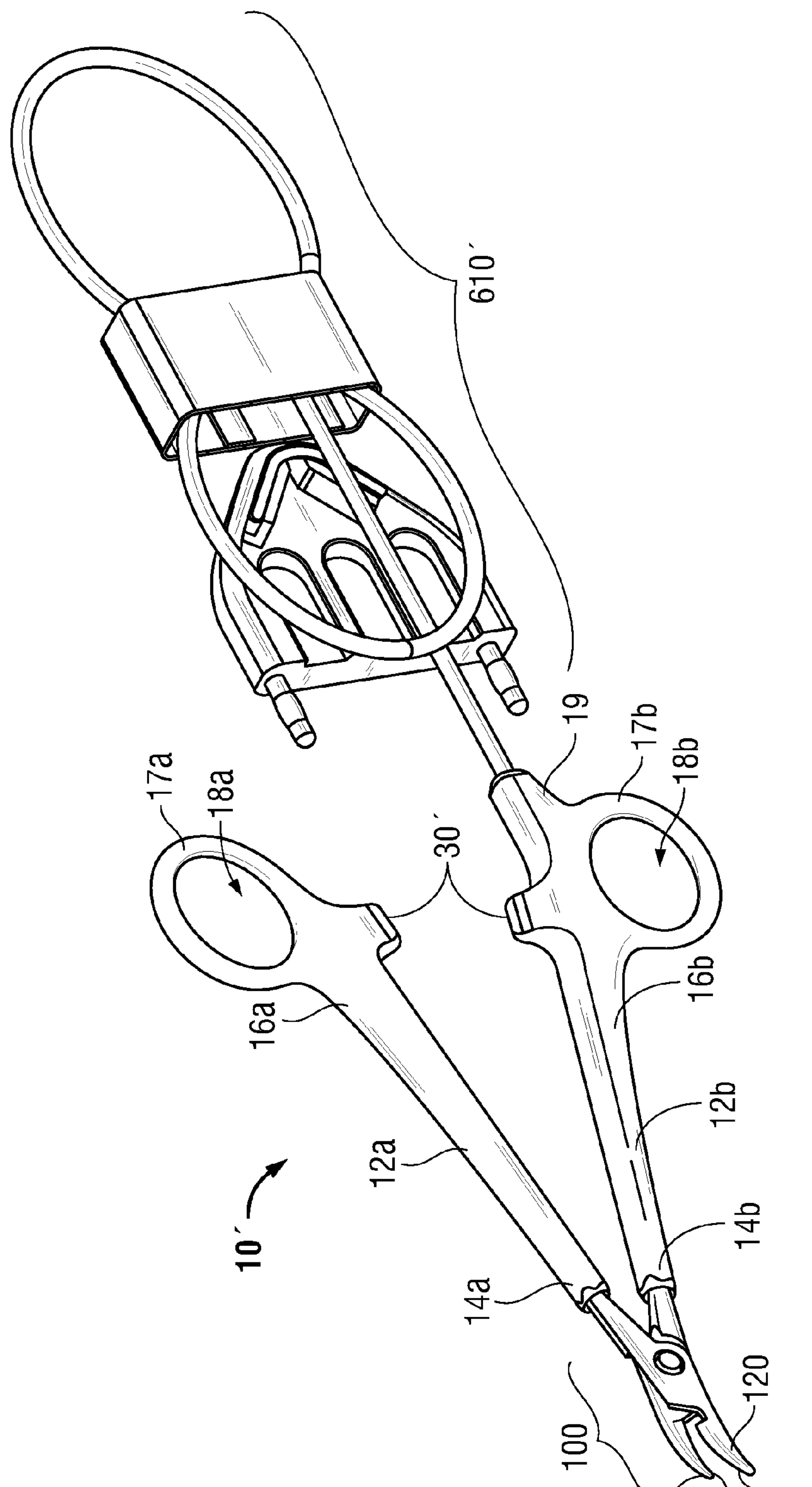
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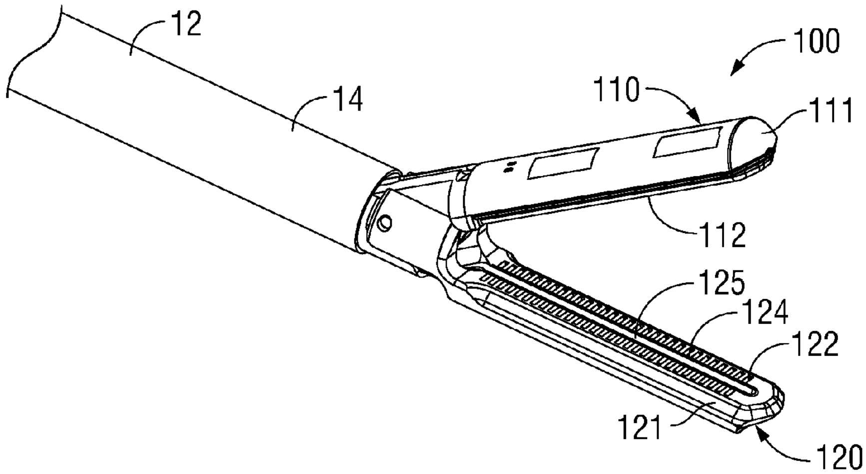
FIG. 2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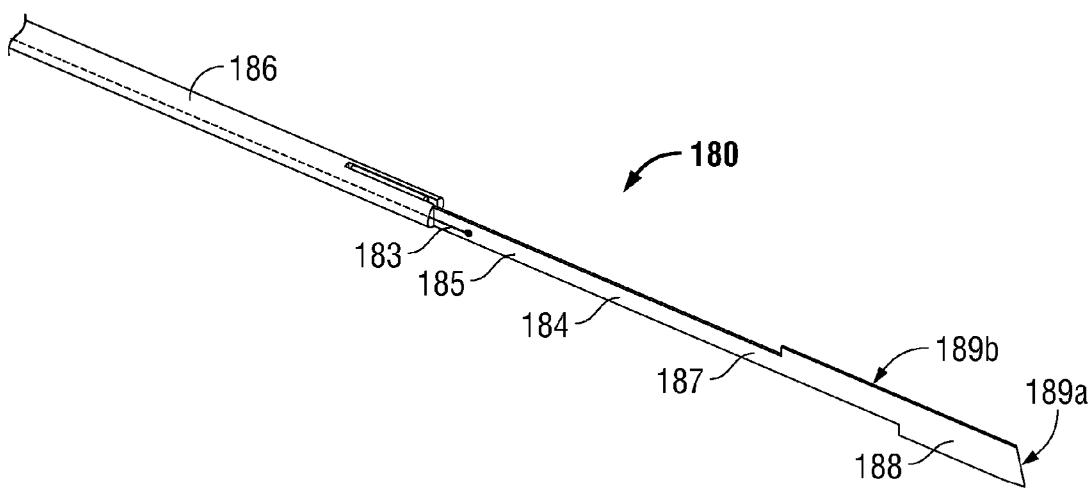
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FIG. 4

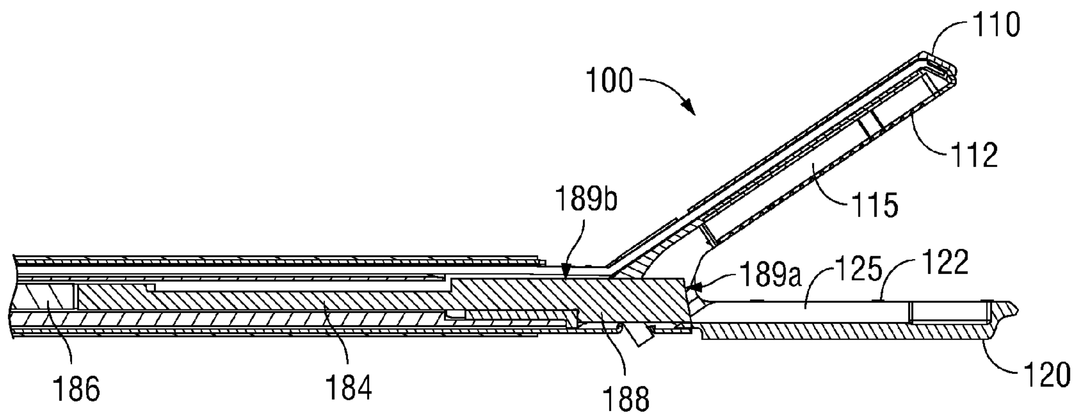


FIG. 5A

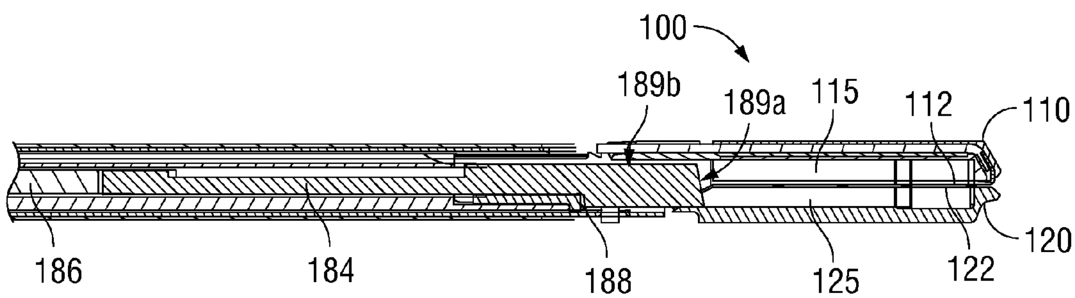
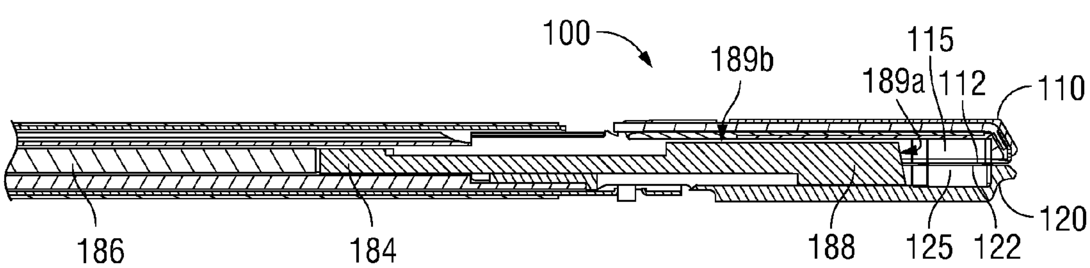


FIG. 5B



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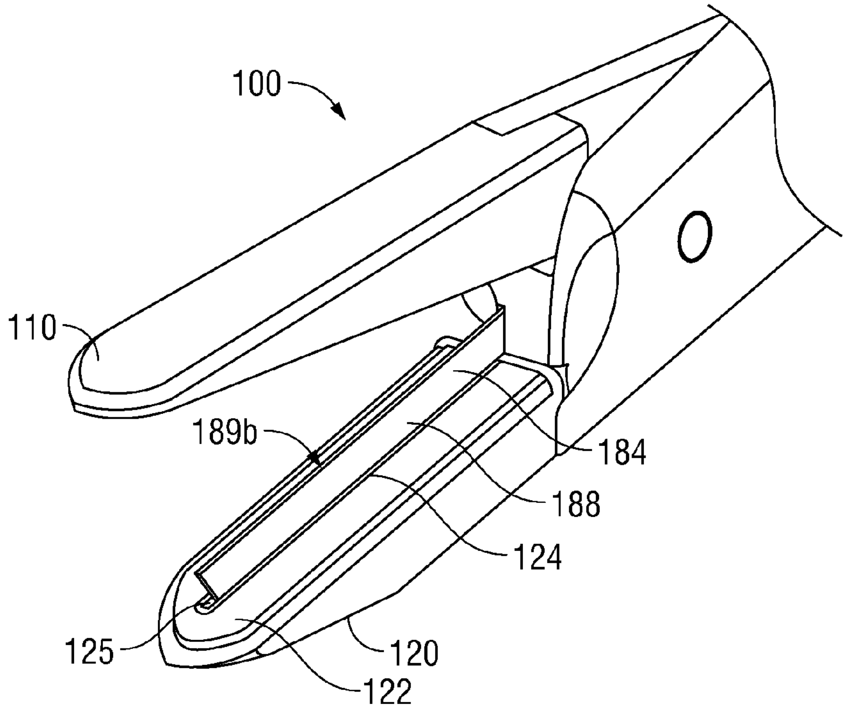
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FIG. 6A

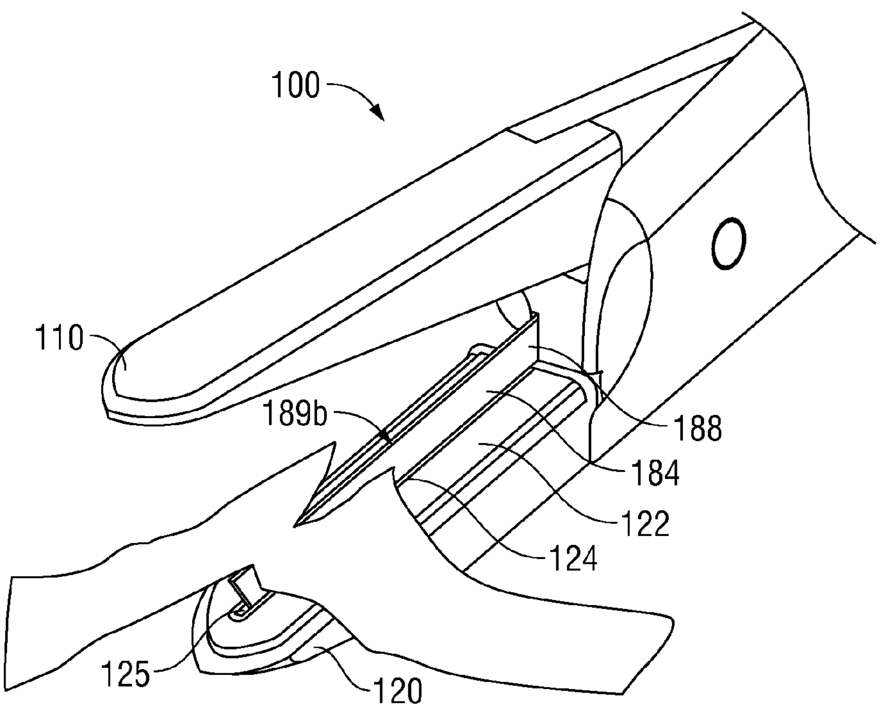
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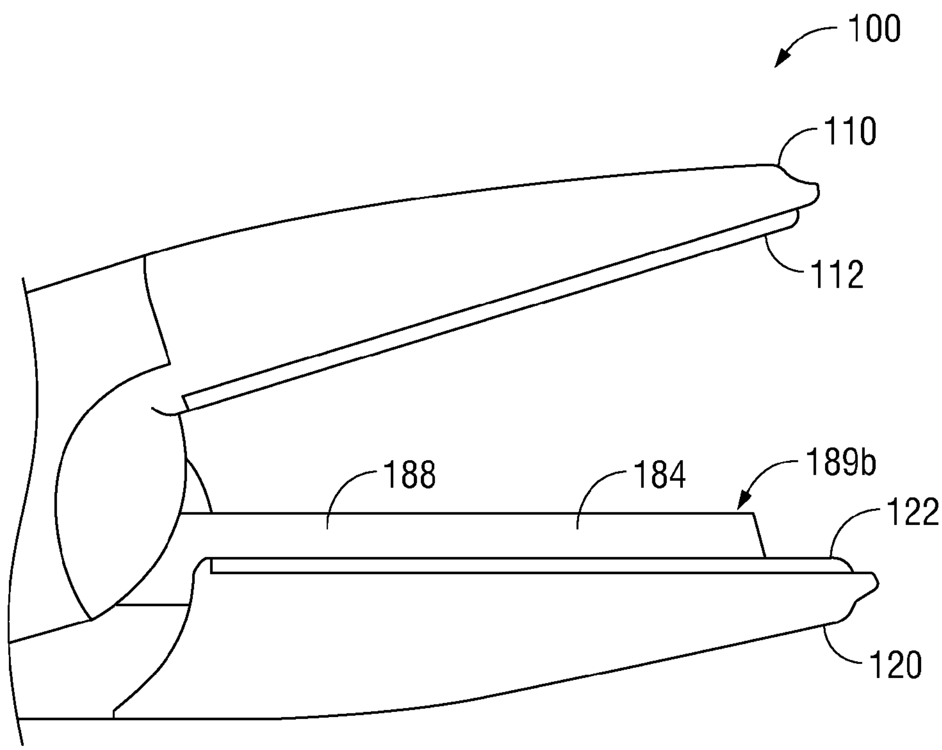
FIG. 6B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184
189b
122
120

FIG. 7A

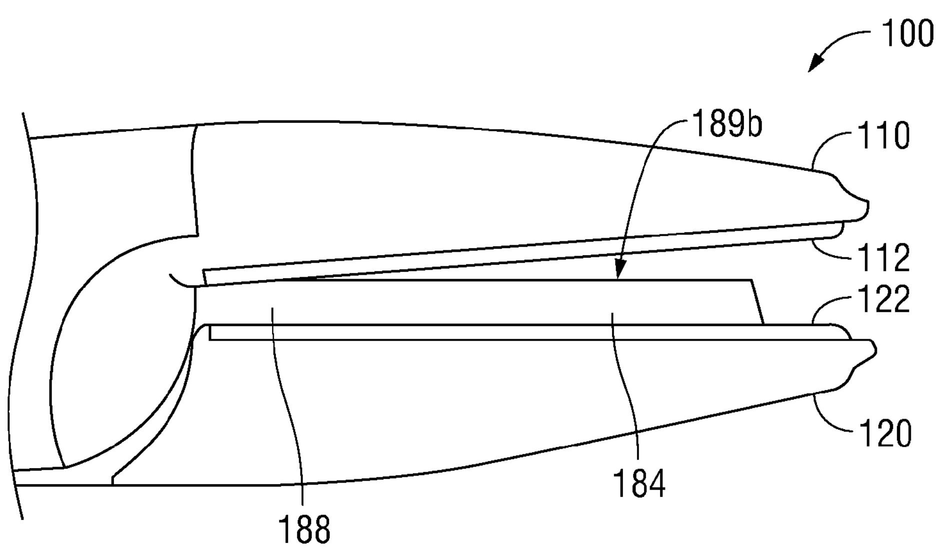
100
189b
110
112
122
120
184
188

FIG. 7B

SURGICAL FORCEPS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of U.S. patent application Ser. No. 13/293,754, filed on Nov. 10, 2011, the entire contents of which are incorporated herein by reference.

BACKGROUND

1. Technical Field

The present disclosure relates to surgical instruments and, more particularly, to surgical forceps for grasping, sealing and/or dissecting tissue.

2. Background of Related Art

A forceps is a plier-like instrument which relies on mechanical action between its jaws to grasp, clamp and constrict vessels or tissue. Electrosurgical forceps utilize both mechanical clamping action and electrical energy to affect hemostasis by heating tissue and blood vessels to coagulate and/or cauterize tissue. Certain surgical procedures require more than simply cauterizing tissue and rely on the unique combination of clamping pressure, precise electrosurgical energy control and gap distance (i.e., distance between opposing jaw members when closed about tissue) to "seal" tissue, vessels and certain vascular bundles.

Typically, once a vessel is sealed, the surgeon has to accurately sever the vessel along the newly formed tissue seal. Accordingly, many vessel sealing instruments have been designed which incorporate a knife or blade member that effectively severs the tissue after forming a tissue seal. In certain instances, it may be necessary to dissect, or cut through tissue in order to reach an underlying vessel (or vessels), or for other purposes.

SUMMARY

As used herein, the term "distal" refers to the portion that is being described which is further from a user, while the term "proximal" refers to the portion that is being described which is closer to a user. The terms "knife" and "tissue-cutting surface," as used herein, do not necessarily mean a component, or portion thereof, that includes a sharp cutting edge for mechanical cutting. Rather, "knife" and "tissue-cutting surface" are used herein to more generally refer to those components, or portions thereof, that are used to cut tissue, e.g., a blunt component or surface for electrical tissue cutting, an edge or corner to facilitate electrical tissue cutting, a sharpened component or surface for mechanical tissue cutting, or combinations thereof.

Any of the aspects described herein, to the extent consistent, may be used in conjunction with any of the other aspects described herein.

In accordance with one aspect of the present disclosure, a forceps is provided. The forceps includes an end effector assembly having first and second jaw members. One or both of the jaw members is movable relative to the other between a spaced-apart position and an approximated position for grasping tissue therebetween. Each jaw member includes an electrically-conductive tissue sealing plate that is adapted to connect to a source of energy. The tissue sealing plates are selectively energizable independently of one another and are configured to conduct energy therebetween and though tissue to seal tissue. A knife includes a distal tissue-cutting surface and an upper tissue-cutting surface. The knife is selectively

translatable relative to the jaw members between a retracted position and an extended position, wherein the knife extends between the jaw members. The distal tissue-cutting surface is configured for dynamic tissue cutting upon translation of the knife from the retracted position to the extended position. The upper tissue-cutting surface is configured for static tissue cutting when the knife is disposed in the extended position. The knife is adapted to connect to the source of energy and is selectively energizable independently of the tissue sealing plates. The knife is configured to conduct energy between the knife and one or both of the tissue sealing plates and through tissue to electrically cut tissue.

In one aspect, a handle assembly is provided for selectively moving the jaw members between the spaced-apart and approximated positions.

In another aspect, a trigger assembly is provided for selectively translating the knife between the retracted and extended positions.

In another aspect, a first activation switch is provided for selectively energizing the tissue sealing plate of the first jaw member and a second activation switch is provided for selectively energizing the tissue sealing plate of the second jaw member.

In yet another aspect, a knife actuation switch is provided for selectively energizing the knife.

In still another aspect, the knife and the tissue sealing plates of the first and second jaw members are energizable to conduct energy therebetween and through tissue to electrically cut tissue when the knife is translated between the retracted and extended positions.

In still yet another aspect, the knife and the tissue sealing plate of the second jaw member are energizable to conduct energy therebetween and through tissue to electrically cut tissue via tenting when the jaw members are disposed in the spaced-apart position and the knife is disposed in the extended position.

In another aspect, the knife and the tissue sealing plate of the first jaw member are energizable to conduct energy therebetween and through tissue to electrically cut tissue via scissor-cutting.

In another aspect, one or more insulators are disposed between the knife and the tissue sealing plates. The insulators are configured to inhibit contact between the knife and the tissue sealing plates.

A method of surgery is also provided in accordance with the present disclosure. The method includes providing a forceps having an end effector assembly including first and second jaw members. Each jaw member includes an electrically-conductive tissue sealing plate adapted to connect to a source of energy. A knife is selectively translatable between the first and second jaw members. The method further includes moving the jaw members to an approximated position relative to one another to grasp tissue therebetween, energizing the tissue sealing plate of one (or both) of the first and second jaw members to seal tissue grasped between the jaw members, moving the jaw members to a spaced-apart position relative to one another, deploying the knife between the jaw members, overlaying the tissue seal across an upper edge of the knife, and moving the end effector assembly transversely relative to tissue to cut tissue via tenting.

In one aspect, the knife is adapted to connect to the source of energy. In such an aspect, the knife may be energized to electrically cut tissue via tenting. The forceps may further include a knife actuation switch for selectively energizing the knife.

In another aspect, the forceps includes a trigger assembly for selectively deploying the knife between the jaw members, e.g., for translating the knife between a retracted position and an extended position.

In yet another aspect, the forceps includes a handle assembly for moving the jaw members between the spaced-apart position and the approximated position.

In still another aspect, the forceps includes a first activation switch for selectively energizing the tissue sealing plate of the first jaw member and a second activation switch for selectively energizing the tissue sealing plate of the second jaw member.

A method of surgery provided in accordance with another aspect of the present disclosure includes providing a forceps according to any of the above aspects. The method further includes moving the jaw members to an approximated position relative to one another to grasp tissue therebetween, energizing the tissue sealing plate of one (or both) of the first and second jaw members to seal tissue grasped between the jaw members, opening the jaw members relative to one another, deploying the knife between the jaw members, positioning the tissue seal between the jaw members, and moving the jaw members from the spaced-apart position to the approximated position to scissor-cut tissue along the tissue seal.

In one aspect, the knife is adapted to connect to the source of energy. In such an aspect, the knife may be energized to electrically scissor-cut tissue. The forceps may further include a knife actuation switch for selectively energizing the knife.

BRIEF DESCRIPTION OF THE DRAWINGS

Various aspects of the present disclosure are described in detail with reference to the drawing figures wherein like reference numerals identify similar or identical elements:

FIG. **1** is a front, perspective view of an endoscopic surgical forceps configured for use in accordance with the present disclosure;

FIG. **2** is a front, perspective view of an open surgical forceps configured for use in accordance with the present disclosure;

FIG. **3** is an enlarged, front, perspective view of an end effector assembly configured for use with the forceps of FIG. **1** or **2**;

FIG. **4** is a perspective view of a knife assembly configured for use with the forceps of FIG. **1** or **2**;

FIG. **5**A is a longitudinal, cross-sectional view of the end effector assembly of FIG. **3**, wherein the jaw members are shown in a spaced-apart position and wherein the knife assembly is shown in a retracted position;

FIG. **5**B is a longitudinal, cross-sectional view of the end effector assembly of FIG. **3**, wherein the jaw members are shown in an approximated position and wherein the knife assembly is shown in the retracted position;

FIG. **5**C is a longitudinal, cross-sectional view of the end effector assembly of FIG. **3**, wherein the jaw members are shown in an approximated position and wherein the knife assembly is shown in an extended position;

FIG. **6**A is a front, perspective view of the end effector assembly of FIG. **3**, wherein the jaw members are shown in the spaced-apart position and wherein the knife assembly is shown in the extended position;

FIG. **6**B is a front, perspective view of the end effector assembly of FIG. **3**, wherein the jaw members are in the spaced-apart position and the knife assembly is in the extended position to dissect tissue;

FIG. **7**A is a side view of the end effector assembly of FIG. **3**, wherein the jaw members are shown in the spaced-apart position and wherein the knife assembly is shown in the extended position; and

FIG. **7**B is a side view of the end effector assembly of FIG. **3**, wherein the jaw members are shown moving towards the approximated position and wherein the knife assembly is shown in the extended position.

DETAILED DESCRIPTION

Referring now to FIGS. **1** and **2**, FIG. **1** depicts a forceps **10** for use in connection with endoscopic surgical procedures and FIG. **2** depicts an open forceps **10'** contemplated for use in connection with traditional open surgical procedures. For the purposes herein, either an endoscopic instrument, e.g., forceps **10**, or an open instrument, e.g., forceps **10'**, may be utilized in accordance with the present disclosure. Obviously, different electrical and mechanical connections and considerations apply to each particular type of instrument; however, the novel aspects with respect to the end effector assembly and its operating characteristics remain generally consistent with respect to both the open and endoscopic configurations.

Turning now to FIG. **1**, an endoscopic forceps **10** is provided defining a longitudinal axis "X-X" and including a housing **20**, a handle assembly **30**, a rotating assembly **70**, a trigger assembly **80**, and an end effector assembly **100**. Forceps **10** further includes a shaft **12** having a distal end **14** configured to mechanically engage end effector assembly **100** and a proximal end **16** that mechanically engages housing **20**. Forceps **10** also includes electrosurgical cable **610** that connects forceps **10** to a generator (not shown) or other suitable power source, although forceps **10** may alternatively be configured as a battery powered instrument. Cable **610** includes wires (not shown) extending therethrough that has sufficient length to extend through shaft **12** in order to provide electrical energy to at least one of the sealing plates **112**, **122** of jaw members **110**, **120**, respectively, of end effector assembly **100**, e.g., upon activation of activation switch **90**.

With continued reference to FIG. **1**, handle assembly **30** includes a fixed handle **50** and a moveable handle **40**. Fixed handle **50** is integrally associated with housing **20** and movable handle **40** is moveable relative to fixed handle **50**. Rotating assembly **70** is rotatable in either direction about longitudinal axis "X-X" to rotate end effector **100** about longitudinal axis "X-X." Housing **20** houses the internal working components of forceps **10**.

End effector assembly **100** is shown attached at a distal end **14** of shaft **12** and includes a pair of opposing jaw members **110**, **120**. Each of the jaw members **110**, **120** includes an electrically-conductive tissue sealing plate **112**, **122**, respectively. End effector assembly **100** is designed as a unilateral assembly, e.g., where jaw member **120** is fixed relative to shaft **12** and jaw member **110** is moveable relative to shaft **12** and fixed jaw member **120** (although the reverse configuration is also contemplated). However, end effector assembly **100** may alternatively be configured as a bilateral assembly, i.e., where both jaw member **110** and jaw member **120** are moveable relative to one another and to shaft **12**. A knife assembly **180** (FIGS. **4**-**5**C) is disposed within shaft **12** and a knife channel **115**, **125** (FIGS. **5**A-**5**C) is defined within one or both jaw members **110**, **120** to permit reciprocation of a knife **184** (FIGS. **4**-**5**C) therethrough, e.g., via actuation of a trigger **82** of trigger assembly **80**. The particular features of end effector assembly **100** and knife assembly **180** (FIGS. **4**-**5**C) will be described in greater detail hereinbelow.

Continuing with reference to FIG. **1**, moveable handle **40** of handle assembly **30** is ultimately connected to a drive assembly (not shown) that, together, mechanically cooperate to impart movement of jaw members **110**, **120** between a spaced-apart position and an approximated position to grasp tissue disposed between sealing plates **112**, **122** of jaw members **110**, **120**, respectively. As shown in FIG. **1**, moveable handle **40** is initially spaced-apart from fixed handle **50** and, correspondingly, jaw members **110**, **120** are in the spaced-apart position. Moveable handle **40** is movable from this initial position to a depressed position to move jaw members **110**, **120** to the approximated position for grasping tissue therebetween (see FIGS. **5**B-**5**C).

Referring now to FIG. **2**, an open forceps **10'** is shown including two elongated shafts **12***a*, **12***b*, each having a proximal end **16***a*, **16***b* and a distal end **14***a*, **14***b*, respectively. Similar to forceps **10** (FIG. **1**), forceps **10'** is configured for use with end effector assembly **100**. More specifically, end effector assembly **100** is attached to distal ends **14***a*, **14***b* of shafts **12***a*, **12***b*, respectively. As mentioned above, end effector assembly **100** includes a pair of opposing jaw members **110**, **120** that are pivotably coupled to one another. Each shaft **12***a*, **12***b* includes a handle **17***a*, **17***b* disposed at the proximal end **16***a*, **16***b* thereof. Each handle **17***a*, **17***b* defines a finger hole **18***a*, **18***b* therethrough for receiving a finger of the user. As can be appreciated, finger holes **18***a*, **18***b* facilitate movement of shafts **12***a*, **12***b* relative to one another which, in turn, pivots jaw members **110**, **120** from an open position, wherein jaw members **110**, **120** are disposed in spaced-apart relation relative to one another, to a closed position, wherein jaw members **110**, **120** cooperate to grasp tissue therebetween.

A ratchet **30'** may be included for selectively locking jaw members **110**, **120** relative to one another at various positions during pivoting. Ratchet **30'** may include graduations or other visual markings that enable the user to easily and quickly ascertain and control the amount of closure force desired between jaw members **110**, **120**.

With continued reference to FIG. **2**, one of the shafts, e.g., shaft **12***b*, includes a proximal shaft connector **19** that is designed to connect forceps **10'** to a source of electrical energy such as an electrosurgical generator (not shown). Proximal shaft connector **19** secures an electrosurgical cable **610'** to forceps **10'** such that the user may selectively apply electrosurgical energy to electrically-conductive tissue sealing plates **112**, **122** of jaw members **110** and **120**, respectively, as needed.

Forceps **10'** may further include a knife assembly **180** (FIGS. **4**-**5**C) disposed within either of shafts **12***a*, **12***b* and a knife channel **115**, **125** (FIGS. **5**A-**5**C) defined within one or both of jaw members **110**, **120**, respectively, to permit reciprocation of a knife **184** (FIGS. **5**-**8**C) therethrough.

Turning now to FIG. **3**, end effector assembly **100**, including jaw members **110**, **120** is configured for use with either forceps **10** or forceps **10'**, discussed above, or any other suitable surgical instrument capable of pivoting jaw members **110**, **120** relative to one another between a spaced-apart position and an approximated position for grasping tissue therebetween. However, for purposes of simplicity and consistency, end effector assembly **100** will be described hereinbelow with reference to forceps **10** only.

Jaw members **110**, **120**, as shown in FIG. **3**, each include an outer, insulative jaw housing **111**, **121** and an electrically-conductive tissue sealing plate **112**, **122** disposed atop respective jaw housings **111**, **121** in opposed relation relative to one another. Tissue sealing plates **112**, **122** are adapted to connect to a source of electrical energy, e.g., electrosurgical energy, independently of one another such that, as will be described in

detail below, either or both of tissue sealing plates **112**, **122** may be selectively energized, depending on a particular purpose. Activation switch **90** (FIG. **1**) is selectively actuatable to control the supply of energy to tissue sealing plates **112**, **122**. More specifically, activation switch **90** (FIG. **1**) may include first and second switch components **90***a*, **90***b* (FIG. **1**) to facilitate selective activation of either or both of tissue sealing plates **112**, **122**.

One or both of jaw members **110**, **120** includes a longitudinally-extending knife channel **115**, **125** (FIGS. **5**A-**5**C) that, as mentioned above, is configured to permit reciprocation of a knife **184** (FIGS. **4**-**5**C) therethrough. An insulator **124** lines each of knife channels **115**, **125** to electrically isolate knife **184** (FIG. **4**) from tissue sealing plates **112**, **122**.

Turning now to FIG. **4**, knife assembly **180** generally includes a knife **184** and a knife bar **186**. Knife **184** is coupled to a knife bar **186** at the proximal end **185** of knife **184** and extends distally from knife bar **186** to define a tissue-cutting portion **188** at the distal end **187** thereof. Tissue-cutting portion **188** of knife **184** defines both a distal tissue-cutting surface **189***a* to facilitate cutting of tissue as knife **184** is translated longitudinally relative to tissue and an upper tissue-cutting surface **189***b* extending along the length of tissue-cutting portion **188** to facilitate cutting of tissue as knife **184** is translated transversely relative to tissue. Tissue-cutting surfaces **189***a*, **189***b* may define sharpened-blade configurations, dull-blade configurations, blunt configurations, or combinations thereof (e.g., distal tissue-cutting surface **189***a* may define a sharpened-blade, while upper tissue-cutting surface **189***b* defines a blunt configuration, although the reverse configuration or other configurations are also contemplated). Further, tissue-cutting surfaces **189***a*, **189***b* may define various different edge or corner configurations to concentrate electrical current and facilitate electrical cutting of tissue.

With continued reference to FIG. **4**, knife **184** is coupled to a source of energy, e.g., electrosurgical energy, via lead wire **183**. Lead wire **183** extends from knife **184** proximally through shaft **12** (FIG. **1**), ultimately coupling to a source of energy, e.g., to a portable generator (not shown) disposed within housing **20** (for battery-powered instruments), or to an external generator (not shown) via cable **610** (FIG. **1**). A knife activation switch **92** (FIG. **1**) disposed on housing **20** (FIG. **1**) is selectively activatable to energize knife **184**, e.g., to control the supply of energy from lead wire **183** to knife **184**.

Turning now to FIGS. **1**, **3**, and **5**A-**7**B, end effector assembly **100** is configured to operate in various different modes and to transition efficiently between the various different modes of operation. As such, end effector assembly **100** is capable of performing a variety of surgical tasks without requiring the use of additional instrumentation and without requiring withdrawal of end effector assembly **100** to transition end effector assembly **100** to a different mode of operation. In particular, end effector assembly **100** is configured at least for: grasping tissue between jaw members **110**, **120**; sealing tissue grasped between jaw members **110**, **120**; mechanically cutting tissue grasped between jaw members **110**, **120**; electrically/electromechanically cutting tissue grasped between jaw members **110**, **120**; mechanically cutting tissue with jaw members **110**, **120** disposed in the spaced-apart position; electrically/electromechanically cutting tissue with jaw members **110**, **120** disposed in the spaced-apart position; mechanically scissor-cutting tissue; and electrically/electromechanically scissor-cutting tissue. Each mode of operation is described in detail below.

Referring to FIGS. **1**, **3** and **5**A-**5**C, the use of end effector assembly **100** for grasping, sealing, and/or cutting tissue, e.g., mechanically, electrically, or electromechanically cutting tissue, grasped between jaw members **110**, **120** is described. Initially, with jaw members **110**, **120** disposed in the spaced-apart position (FIG. **5**A), end effector assembly **100** is maneuvered into position such that tissue to be grasped, sealed, and/or cut is disposed between jaw members **110**, **120**. Next, moveable handle **40** is pulled proximally relative to fixed handle **50** such that jaw member **110** is pivoted relative to jaw member **120** from the spaced-apart position to the approximated position to grasp tissue between tissue sealing plates **112**, **122** of jaw members **110**, **120**, respectively (FIG. **5**B). Thereafter, energy may be supplied, e.g., via activation of activation switch **90** to tissue sealing plate **112** and/or tissue sealing plate **122** and conducted through tissue to effect a tissue seal. For example, tissue sealing plate **112** of jaw member **110** may be energized to a first potential, e.g., via activation of first switch component **90***a*, while tissue sealing plate **122** of jaw member **120** is energized to a second potential different from the first (or is not energized), e.g., via activation of second switch component **90***b*, thus creating a potential difference between tissue sealing plates **112**, **122** such that energy is conducted therebetween and through tissue to effect a tissue seal. That is, in this configuration, tissue sealing plate **112** functions as the "active" electrode, while tissue sealing plate **122** functions as the "return" electrode. Other configurations for sealing tissue are also contemplated, e.g., wherein tissue sealing plate **122** is the "active" electrode and wherein tissue sealing plate **112** is the "return" electrode.

Once tissue sealing is complete (or where only grasping and cutting is desired), knife **184** may be advanced from the retracted position (FIG. **5**B) to the extended position (FIG. **5**C), e.g., via activation of trigger **82**, such that knife **184** is translated through knife channels **115**, **125** of jaw members **110**, **120**, respectively, to cut tissue grasped between jaw members **110**, **120**. As knife **184** is translated distally though knife channels **115**, **125** of jaw members **110**, **120**, respectively, distal tissue-cutting portion **189***a* of knife **184** mechanically cuts or dissects tissue grasped between jaw members **110**, **120**.

Continuing with reference to FIGS. **1**, **3** and **5**A-**5**C, knife **184** may be energized as knife **184** is advanced through jaw members **110**, **120** to facilitate cutting of tissue. More specifically, knife activation switch **92** may be activated to supply energy to knife **184** (the "active" electrode), via lead wire **183** (FIG. **4**), for electrically/electromechanically cutting tissue grasped between jaw members **110**, **120**. In this mode, tissue sealing plates **112**, **122** are not energized (or are energized to a different potential from knife **184**), thus functioning as the "return" electrode. In use, as the energized knife **184** is translated through jaw members **110**, **120**, energy is conducted between distal tissue-cutting surface **189***a* and tissue sealing plates **112**, **122** and through tissue therebetween to electrically cut tissue, while the advancement of distal tissue-cutting surface **189***a* through tissue mechanically cuts tissue. This conduction of energy through tissue for electrical cutting also results in some coagulation of tissue adjacent the cut line. Insulators **124** lining knife channels **115**, **125** of jaw members **110**, **120**, respectively, inhibit contact between knife **184** and tissue sealing plates **112**, **122** as knife **184** is translated therethrough, thus inhibiting shorting of the electrodes.

The particular mode of end effector assembly **100**, e.g., grasping, tissue sealing, mechanical tissue cutting, and/or electrical tissue cutting, used for sealing and/or dividing tissue, may depend on the size and/or composition of tissue, the procedure to be performed, other anatomical considerations, etc. For example, for certain tissue, e.g., more avascular tissue, or where rapid dissection is required, it may be sufficient to grasp tissue between jaw members **110**, **120**, energize knife **184**, and advance knife **184** between jaw members to electrically cut tissue, while the coagulation adjacent the cut line sufficiently reduces bleeding. For other tissue, e.g., more vascular tissue, or where rapid dissection is not as important, tissue may be grasped and sealed prior to advancement of knife **184** to cut tissue along the tissue seal. In this mode, the size and/or composition of tissue, or other factors, may dictate whether mechanical cutting or electrical/electromechanical cutting is required.

With reference to FIGS. **1**, **3** and **6**A-**6**B, the use of end effector assembly **100** for open-jaw tissue cutting, e.g., wherein jaw members **110**, **120** are disposed in the spaced-apart position, is described. As mentioned above, knife **184** includes an upper tissue-cutting surface **189***b* extending along the length of tissue-cutting portion **188** of knife **184**. Thus, with jaw members **110**, **120** disposed in the spaced-apart position and with knife **184** in the extended position, upper tissue-cutting surface **189***b* is exposed such that end effector assembly **100** may be advanced transversely through tissue to cut tissue using upper tissue-cutting surface **189***b* of knife **184**.

In use, with jaw members **110**, **120** disposed in the spaced-apart position, end effector assembly **100** is moved into positioned adjacent tissue to be cut. At this point, or prior to, knife **184** is advanced to the extended position, e.g., via activation of trigger **82** of trigger assembly **80**. Knife **184** is retained in the extended position via maintaining trigger **82** in an activated, or depressed position, although trigger assembly **80** may also include a locking mechanism (not explicitly shown) for selectively locking knife **184** in the extended position. In the mechanical cutting mode, with knife **184** in the extended position, end effector assembly **100** is advanced transversely relative to tissue to mechanically cut tissue using upper tissue-cutting surface **189***b* of knife **184**, as shown in FIG. **6**B.

In the electrical/electromechanical cutting mode, knife **184** is energized during open-jaw tissue cutting to facilitate cutting of tissue. More specifically, knife activation switch **92** may be activated to supply energy to knife **184** (the "active" electrode) via lead wire **183** (FIG. **4**) for electrically/electromechanically cutting tissue grasped between jaw members **110**, **120**. In this configuration, tissue sealing plate **112** is not energized. Tissue sealing plate **122** is energized to a different potential from that of knife **184**, e.g., via activation of second switch component **90***b*, such that tissue sealing plate **122** functions as the "return" electrode. Insulator **124** lining knife channel **125** of jaw member **120** inhibits contact between knife **184** and tissue sealing plate **122**, thus inhibiting shorting of the electrodes.

Continuing with reference to FIGS. **1**, **3** and **6**A-**6**B, with knife **184** energized as the "active" electrode and with tissue sealing plate **122** energized as the "return" electrode, end effector assembly **100** may be advanced transversely through tissue to electrically/electromechanically cut tissue disposed between jaw members **110**, **120** via tenting. Tenting, as shown in FIG. **6**B, involves positioning end effector assembly **100** such that tissue to be cut lays over upper tissue-cutting surface **189***b* of knife **184** and extends toward jaw member **120** on either side of knife **184** to contact tissue sealing plate **122** of jaw member **120**, thus forming a tent-like configuration. In this configuration, tissue contacts upper tissue-cutting surface **189***b* of knife **184** at the apex of the tent and tissue sealing plate **122** on the sides of the tent such that energy is conducted from knife **184**, through tissue, to tissue sealing plate **122** to electrically cut tissue, while upper tissue-cutting surface **189***b* is advanced through tissue to mechanically cut tissue. The transverse translation of end effector assembly **100** relative to tissue during cutting, i.e., the urging of upper tissue-cutting surface **189***b* of knife **184** into tissue, helps maintain sufficient tension on tissue and helps ensure contact of tissue with tissue sealing plate **122** on either side of knife **184**, thus facilitating the cutting of tissue as end effector assembly **100** is translated transversely therethrough.

It has been found that proper knife height is important in order to achieve optimal tenting. A knife height that is too small may not sufficiently tension tissue, making it more difficult to cut through tissue and insufficiently defining an energy path through tissue. On the other hand, a knife height that is too large may result in too much tenting, e.g., where tissue does not contact or does not sufficiently contact tissue sealing plate **122**, reducing the effective current path through tissue between knife **184** and tissue sealing plate **122**. Further, the sides of knife **184** may be coated with a dielectric, e.g., silicone, kapton, or any other suitable dielectric, to concentrate energy at upper tissue tissue-cutting surface **189***b* of knife **184**, thus creating a more defined current path through tissue to tissue sealing plate **122** during cutting. This dielectric coating is also advantageous when end effector assembly **100** is used in the grasping and electrical/electromechanical tissue mode (see FIGS. **5**A-**5**C) or the electrical/electromechanical scissor-cutting mode (see FIGS. **7**A-**7**B), e.g., the dielectric coating facilitates the concentration of energy at the tissue-cutting surface (distal tissue-cutting surface **189***a*, for the grasping and electrical/electromechanical tissue mode, or upper tissue-cutting surface **189***b*, for the electrical/electromechanical scissor-cutting mode) of knife **184**, thus creating a more defined current path through tissue.

The open-jaw tissue cutting mode (e.g., both the mechanical open-jaw cutting mode and the electrical/electromechanical open-jaw cutting mode) of end effector assembly **100** is particularly advantageous where rapid or repeated tissue cutting (without tissue sealing) is required, e.g., for providing access to underlying tissue. For example, the open-jaw tissue cutting mode allows end effector assembly **100** to continuously cut and advance through tissue (e.g., multiple layers of tissue) in order to efficiently and expediently access underlying tissue or an underlying surgical site. Certain tissue, e.g., smaller-diametered tissue, may be cut using mechanical cutting, while other tissue, e.g., stronger or larger tissue, may necessitate the use of tenting and electrical/electromechanical cutting.

With reference to FIGS. **1**, **3** and **7**A-**7**B, the use of end effector assembly **100** for mechanically or electro-mechanically scissor-cutting tissue is described. As mentioned above, knife **184** includes an upper tissue-cutting surface **189***b* extending along the length of tissue-cutting portion **188** of knife **184**. Thus, with jaw members **110**, **120** disposed in the spaced-apart position and with knife **184** in the extended position, upper tissue-cutting surface **189***b* is exposed. Accordingly, jaw members **110**, **120** may be repeatedly moved between the spaced-apart and approximated positions in scissor-like fashion, e.g., via repeatedly squeezing and releasing moveable handle **40**, to mechanically cut tissue disposed between jaw members **110**, **120**. More specifically, in use, tissue is positioned between jaw members **110**, **120** such that, as jaw members **110**, **120** are moved from the spaced-apart position to the approximated position, upper tissue-cutting surface **189***b* of knife **184** is translated through tissue positioned therebetween and into knife channel **115** (FIGS. **5**A-**5**C) of jaw member **110** to cut tissue, while tissue is held in position between jaw members **110**, **120**.

With continued reference to FIGS. **1**, **3** and **7**A-**7**B, end effector assembly **100** may also be used to electromechanically scissor-cut tissue. For electromechanical scissor-cutting, knife **184** is energized, e.g., via activation of knife activation switch **92**, to function as the "active" electrode, while tissue sealing plate **112** is energized to a different potential, e.g., via activation of first switch component **90***a*, such that tissue sealing plate **112** functions as the "return" electrode. In this configuration, tissue sealing plates **122** is not energized.

In use, in the electrical/electromechanical scissor-cutting mode, tissue is positioned between jaw members **110**, **120** and jaw members **110**, **120** are moved from the spaced-apart position to the approximated position. As jaw members **110**, **120** are moved towards the approximated position, some mechanical cutting is achieved as upper tissue tissue-cutting surface **189***b* of knife **184** is urged into tissue positioned between knife **184** and knife channel 115 (FIGS. **5**A-**5**C) of jaw member **110**. As jaw members **110**, **120** are moved further towards the approximated position, knife **184** and jaw members **110** urge tissue into contact with tissue sealing plate **122** of jaw member **120**, to create a current path through tissue from upper tissue-cutting surface **189***b* of knife **184** to tissue sealing plate **122**, thus allowing conduction of energy therebetween to electrically cut tissue.

The scissor-cutting mode (e.g., both the mechanical and electrical/electromechanical scissor-cutting mode) of end effector assembly **100** is particularly advantageous for cutting stronger and/or lager tissue in that jaw members **110**, **120** retain tissue in position as knife **184** is advanced therethrough. The particular procedure, size and/or composition of tissue, or other factors may dictate whether mechanical cutting is sufficient or whether electrical/electromechanical cutting is necessary.

With reference to FIGS. **1**-**7**B, as detailed above, end effector assembly **100** is configured for use in various modes of operation depending on the position of jaw members **110**, **120** (as controlled by movable handle **40**) and/or knife **184** (as controlled by trigger assembly **80**), and the energization of tissue sealing plates **112**, **122** (as controlled by first and second switch components **90***a*, **90***b*, respectively) and/or knife **184** (as controlled by knife activation switch **92**). End effector assembly **100** is efficiently transitionable between these various different modes by controlling movable handle **40**, trigger assembly **80**, first and second switch components **90***a*, **90***b*, and/or knife activation switch **92**. As such, end effector assembly **100** may not only be used for performing various different surgical procedures, but may also be transitioned between two or more of the above-described modes during the course of a single procedure. For example, end effector assembly **100** may be used to mechanically or electrically/electromechanically cut tissue in the open-jaw cutting mode or scissor cutting mode in order to reach underlying tissue to be sealed and/or divided. End effector assembly **100** may then be used to grasp, seal, and divide (mechanically or electrically/electromechanically) the underlying tissue. Alternatively, end effector assembly **100** may be used to grasp and seal tissue, followed by mechanically or electrically/electromechanically cutting tissue along the tissue seal via moving jaw members **110**, **120** to the approximated position, advancing knife **184** between jaw members **110**, **120**, and cutting tissue (mechanically or electrically/electromechanically) along the tissue seal via tenting or scissor-cutting. However, end effector assembly **100** is not limited to these examples (or any specific combination of modes), but, rather, end effector assembly **100** may be transitioned between any of the above-described modes in any suitable order, i.e., end effector assembly **100** may be specifically tailored to perform a desired surgical procedure.

From the foregoing and with reference to the various figure drawings, those skilled in the art will appreciate that certain modifications can also be made to the present disclosure without departing from the scope of the same. While several embodiments of the disclosure have been shown in the drawings, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of particular embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

What is claimed is:

1. A surgical instrument, comprising:
an end effector assembly, including:
first and second jaw members, at least one of the first and second jaw members movable relative to the other between a spaced-apart position and an approximated position for grasping tissue therebetween, at least one of the first and second jaw members defining an electrically-conductive surface adapted to connect to a source of energy; and
a knife adapted to connect to a source of energy and selectively translatable relative to the first and second jaw members between a retracted position and an extended position wherein the knife extends between the first and second jaw members, the knife translatable between the retracted and extended positions in each of the spaced-apart and approximated positions of the first and second jaw members, the knife configured for dynamic tissue cutting upon translation of the knife from the retracted position to the extended position with the first and second jaw members disposed in the approximated position, the knife configured for static tissue cutting with the knife disposed in the extended position.

2. The surgical instrument according to claim **1**, wherein the knife is configured for static tissue cutting with the knife disposed in the extended position and the first and second jaw members disposed in the spaced-apart position.

3. The surgical instrument according to claim **1**, wherein the knife is configured for static tissue cutting with the knife disposed in the extended position and the first and second jaw members moving between the spaced-apart and approximated positions.

4. The surgical instrument according to claim **1**, further including a handle assembly operably associated with the end effector assembly, the handle assembly including a movable handle selectively actuatable for moving the first and second jaw members from the spaced-apart position to the approximated position.

5. The surgical instrument according to claim **1**, further including a trigger assembly operably associated with the knife, the trigger assembly including a trigger selectively actuatable for translating the knife between the retracted and extended positions.

6. The surgical instrument according to claim **1**, further including:
a first activation switch configured to selectively energize the electrically-conductive surface of the first jaw member; and
a second activation switch configured to selectively energize the electrically-conductive surface of the second jaw member.

7. The surgical instrument according to claim **1**, further including a knife actuation switch configured to selectively energize the knife.

8. The surgical instrument according to claim **1**, wherein the knife and the electrically-conductive surface of at least one of the first and second jaw members are energizable to conduct energy therebetween to electrically cut tissue.

9. The surgical instrument according to claim **1**, wherein the electrically-conductive surfaces of the first and second jaw members are energizable to conduct energy therebetween to seal tissue.

10. The surgical instrument according to claim **1**, wherein the second jaw member is fixed and wherein the first jaw member is movable relative to the second jaw member.

11. The surgical instrument according to claim **10**, wherein the second jaw member defines a knife channel extending longitudinally through an electrically-conductive surface thereof, and wherein, upon translation of the knife from the retracted position to the extended position, the knife is translated at least partially through the knife channel of the second jaw member regardless of whether the first and second jaw members are disposed in the spaced-apart position or the approximated position.

12. The surgical instrument according to claim **11**, wherein the first jaw member defines a knife channel extending longitudinally through an electrically-conductive surface thereof, wherein, upon translation of the knife from the retracted position to the extended position with the first and second jaw members disposed in the approximated position, the knife is translated at least partially through the knife channel of the first jaw member.

13. The surgical instrument according to claim **12**, wherein, upon translation of the knife from the retracted position to the extended position with the first and second jaw members disposed in the spaced-apart position, the knife is spaced-apart from the knife channel of the first jaw member.

14. The surgical instrument according to claim **13**, wherein the knife and the electrically-conductive surface of the second jaw member are energizable to conduct energy therebetween and through tissue to electrically cut tissue via tenting when the first and second jaw members are disposed in the spaced-apart position and the knife is disposed in the extended position.

15. The surgical instrument according to claim **13**, wherein the knife and the electrically-conductive surface of the first jaw member are energizable to conduct energy therebetween and through tissue to electrically cut tissue via scissor-cutting when the knife is disposed in the extended position and the first jaw member moves between the spaced-apart and approximated positions.

16. The surgical instrument according to claim **13**, wherein the knife and the electrically-conductive surface of at least one of the first and second jaw members are energizable to conduct energy therebetween and through tissue to electrically cut tissue when the first and second jaw members are disposed in the approximated position and the knife is translating from the retracted position to the extended position.

17. The surgical instrument according to claim **1**, wherein the knife defines a first tissue-cutting portion configured for use in dynamic tissue cutting and a second tissue-cutting portion configured for use in static tissue cutting.

18. The surgical instrument according to claim **17**, wherein the first tissue-cutting portion of the knife is oriented so as to define a leading end of the knife upon translation of the knife from the retracted position to the extended position.

19. The surgical instrument according to claim **17**, wherein the second tissue-cutting portion is oriented to face the first or second jaw member.

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